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OME EXPERIMENTS ON THE INFLUENCE OF LIGHT AND POISONS ON MARINE COPEPODS, WITH REFERENCE TO THEIR DAILY MIGRATION

BY

W. W. LEPESCHKIN

(Contribution from the Laboratories of the Desert Sanatorium and Institute of Research, Tucson, Arizona)

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SOME EXPERIMENTS ON THE INFLUENCE OF LIGHT AND POISONS ON MARINE COPEPODS, WITH REFERENCE TO THEIR DAILY MIGRATION

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The daily migration of marine copepods from upper to lower layers of sea water is usually ascribed to their phototactic sensitiveness. Some copepods are considered as positively, others as negatively phototactic. It has been pointed out that the kind of their phototaxis may change under laboratory conditions, and it seems very probable that some unknown unfavorable factor under laboratory conditions produces this change.

During my work at the Scripps Institution of Oceanography in June and July, 1930, I made some experiments on the influence of sunlight on copepods. The copepods used were identified by Professor Charles B. Wilson, of the Department of Education of Massachusetts, and I express to him my hearty thanks for his aid.

The copepods taken from the plankton in the morning, with *Paracalanus parvus* prevailing, showed a very marked positive phototaxis in the laboratory room. If they were exposed in test tubes to direct sunlight, however, they migrated in some minutes to the side of the tube opposite the sun, thus showing accordingly a negative phototaxis. The same change in phototaxis was shown by *Oithona similis* and *Corycaeus venustus,* which sometimes prevail in the morning plankton. The copepods occurring at the sea surface at night (for instance at 9:00 P.M.), at the end of June, among which were *Acartia clausii* and *A. tonsa, Oithona brevicornis* and *O. nana, Corycaeus rostratus, Oncaea venusta,* and *Euterpe acutifrons,* proved to be negatively phototactic even in the laboratory room, and they were all the more negatively phototactic when they were exposed to direct sunlight on the next morning, provided they had been kept in constantly running sea water (the outflow tube was provided with a small funnel covered by bolting cloth).

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It is evident from the above experiments that the intensity of light plays an important part in the movement of copepods. It may be supposed also that direct sunlight is injurious to all kinds of copepods and causes them to swim to a safer place. Although the copepods represent complex organisms with well developed nervous processes, in their phototaxis they are suggestively similar to swimming algae which change their positive to negative phototaxis when the intensity of light is too strong.

That direct sunlight is injurious to copepods is shown by the following experiments. The exposure of various kinds of copepods to direct sunlight decreases their resistance against poisons, for instance, against mercury bichloride.

Sea water containing copepods (the experiments were made on *Paracalanus parvus, Oncaea venusta,* and *Euterpe acutifrons*) was poured into the test tubes. There were twelve tubes and each tube contained about thirty animals in 8 cc of sea water. Half of the tubes were wrapped in black sateen (three layers), all tubes were immersed in running water of an approximately constant temperature (22° C), and then exposed to direct sunlight at noon. After two hours 0.1 cc of differently concentrated solutions of mercury bichloride was added to each tube, and the time necessary to stop the movement of all animals was measured with a stop watch. The stoppage of movement was irreversible and may be considered as death. The experiment was repeated six times and the variation of the time for different tubes with the same concentration of mercury bichloride did not exceed 10 per cent of the average time given below. The animals which had been in the dark showed the following average duration of life in the solutions of mercury bichloride:

Concentration of $HgCl_2$ in per cent	0.025	0.0125	0.006	0.003	0.0013	0.00026
Survival time in minutes	1.7	2.3	3.8	6.4	10.8	41

The dependence of the life duration upon the concentration of the poison may be expressed approximately by the formula: $\frac{l}{t} = KC^p$ where t is the survival time, C is the concentration, and K and p are constants. The corresponding curve is a so-called adsorption curve. In our case $K = 11.4$ and $p = 0.74$. The copepods which had been exposed to direct sunlight showed a curve of the same form but it was nearer the axis of concentration; in other words the time necessary to kill the animals was shortened, as is seen below:

Concentration of $HgCl_2$ in per cent	0.003	0.0013	0.00026
Survival time in minutes	4.5	7.5	30

Thus the exposure to direct sunlight decreases the resistance of copepods to poisons, and is therefore injurious to them. This conclusion concerns, of course, only visible rays of sunlight. The ultraviolet rays of the solar spectrum proved to increase the resistance of the animals to poisons if the exposure to the rays was short. The visible part of sunlight was absorbed in these experiments by the filter 586-A (purple, ultraviolet) produced by the Corning Glass Company. This filter was used as a cover for one of the Petri dishes in which the animals were swimming in sea water. The resistance of the animals was increased by 15 per cent if the exposure lasted not longer than ten minutes. If the exposure was more than one hour the resistance decreased, however. It seems that both effects of ultraviolet rays (harmful and useful) are independent of each other. Indeed, if the dish with the copepods was covered by a quartz plate or open and exposed to direct sunlight, a smaller decrease of resistance was observed than in the case where the copepods had been covered by a glass; sometimes no decrease of resistance could be discovered in the first case even if the exposure lasted more than one hour. It may therefore be concluded that ultraviolet rays protect the animals from the injurious effect of visible light.

In nature, both parts of sunlight, visible and ultraviolet, permeate the upper layers of sea water, but ultraviolet rays of short wave length (which are the most active in protecting copepods) are absorbed to a greater degree by sea water than are the more harmful visible rays (blue and violet). Thus the protective effect of ultraviolet rays is more effective on the sea surface. It is therefore possible that the copepods which are less sensitive to light and show a negative phototaxis only in case of an illumination by direct sunlight come to the sea surface because they are more protected there from the injurious effect of the visible rays of direct sunlight.

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